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Contribution to the Themed Section: 'Marine Harvesting in the Arctic'

Introduction: Marine Harvesting in the Arctic

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In a warmer Arctic, living conditions will change at all trophic levels of the marine ecosystem. Increased air and water temperatures will likely substantially reduce ice coverage. Trophic interactions might change and increased competition between resident Arctic species and invasive species seems likely. A theme session on "Marine harvesting in the Arctic" was held at the international Arctic Frontiers Conference in Tromsø, Norway, in January 2013. The theme session partitioned the topic into two sub-sessions: (i) introduced species, immigration and fate of resident species and (ii) prospective harvesting of marine biological resources in the Arctic. The four articles that follow this introduction are based on presentations made at the Arctic Frontiers theme session. These articles cover topics such as: how ice breeding seals (*Pagophilus groenlandicus*) can cope with ice retention in the Northwest Atlantic, how planktonic stages of the resident polar cod (*Boreogadus saida*) and the pole-ward expanding Pacific sand lance (*Ammodytes hexapterus*) may compete for food in the warming Beaufort Sea, and how the introduced red king crab (*Paralithodes camtschaticus*) disperse in the Barents Sea. The fourth article shows how differences in the life-history strategies of keystone zooplankton species will likely affect future productivity of commercial fisheries in polar regions.

Keywords: climate change, ice retention, introduced species, life-history strategies, pole-ward expansion, resource extraction.

In a warmer Arctic, the living conditions will change at all trophic levels of the marine ecosystem. Increased air and water temperatures are assumed to reduce the ice-covered areas substantially. Trophic interactions will change as well, and increased competition between resident Arctic species and invasive temperate species seems probable. The higher trophic levels, which usually sustain the harvest in the Arctic, will presumably be particularly challenged by an alteration of the forage base with potential losses of some of their traditionally favored fat-rich prey species. These predicted changes will challenge traditional harvest activities in the Arctic, but may also generate new possibilities. Over the coming decades it is likely that we will see increased impacts from human activities and ship traffic in the previously inaccessible ice-covered areas. These and related questions were addressed at a theme session on "Marine harvesting in the Arctic" held at the international Arctic Frontiers Conference in Tromsø, Norway, in January 2013. The session was divided into two sub-sessions:

Introduced species, immigration and fate of resident species

Climate warming in the Arctic may enhance the introduction of exotic species, invasion of temperate species, and change/increase the distribution of resident species. The challenge today is to be able to identify and forecast changes that will affect the harvest of marine resources. Following from this, the types of questions taken up were: Threshold species and vectors for spreading; Consequences of a reduction in ice cover; Impacts of pole-ward expansion of temperate species; Altered trophic relations, life-history traits and resilience.

Prospective harvest of marine biological resources in the Arctic

A northward movement of commercial species is already observed and reduced ice cover of the Arctic Ocean may enhance overall production. Will this development generate new opportunities for commercial, aboriginal, and recreational fisheries? Will species that are unexploited today be harvested for traditional fishery/hunting and as a source for bioprospecting? Increased ship traffic associated with harvest of marine resources, transport, and tourism is likely to increase anthropogenic impacts on Arctic marine systems. Such effects may challenge the resilience of ecosystems and lead to unwanted and irreversible outcomes. In this context, the types of questions taken up were: Challenges in traditional marine harvest due to climate changes; Future harvest opportunities

on introduced and immigrating species; Impact of increased human activities in the Arctic.

The Arctic Frontiers theme session gave participating scientists a good opportunity to address questions related to how the combined effects of a changing climate on oceanographic processes, species distribution and foodweb dynamics are likely to influence marine resources and, thereby, the potential for harvest at high latitudes. Overall, the session had a pan-Arctic profile, with four invited keynote speakers and 37 oral and poster presentations. Most of these presented more specific and regionally focused research. All the results presented fill important gaps in our knowledge of little-studied research topics and species. From this rich spectrum of contributions to the session, four appear in the article theme set that follows this introduction.

The red king crab (*Paralithodes camtschaticus*) was intentionally introduced to the eastern Russian parts of the Barents Sea in the 1960s to create a new resource. Addressing the dispersal rate westwards and into Norwegian waters of this introduced species, and using tag-recapture data obtained over the period 1994–2011 (when more than 30,000 crabs were tagged), Windsland *et al.* (2014) concluded that there are large individual differences in dispersal ability, and the range expansion of red king crab is a result of (i) the presence of long-distance dispersers and (ii) time-dependent slow migration by short distance dispersers.

Stenson and Hammill (2014) examined whether ice breeding harp seals (*Pagophilus groenlandicus*) can adapt to the habitat loss that follows ice retention. They observed that harp seals responded to poor ice conditions differently, depending on the presence or absence of ice at the beginning of the pupping period. If no ice was present, females moved away from their traditional whelping areas to find suitable ice. If small amounts of ice were present, females gave birth even if the ice was too thin to sustain the pups, resulting in high pup mortality. There was no evidence to indicate that harp seals pupped on land even in areas where ice was absent. Young seals that did drift to shore had high levels of abandonment and mortality.

The boreal Pacific sand lance (*Ammodytes hexapterus*) was recently detected in the southeastern Beaufort Sea (Canadian Arctic), where it is the second most abundant ichthyoplankton species after the resident polar cod (*Boreogadus saida*). Falardeau *et al.* (2014) contrasted the hatching periods, growth, prey selectivity, and feeding success of the planktonic stages of the two species, and concluded that any competition between the larval stages was unlikely. At the current time, interspecific competition for food is unlikely as well, but is predicted to increase with a climate-related reduction in the size of zooplankton prey and an increase in the abundance of sand lance.

McBride *et al.* (2014) suggest that the combined effects of a changing climate on oceanographic processes and foodweb dynamics are likely to influence future fisheries in polar regions in very different ways. Differences in the life history strategies of the key zooplankton species (Antarctic krill in the Southern Ocean and *Calanus* copepods in the Arctic) will likely affect future productivity of fishery species and fisheries. A review of published studies suggests that if an increase in open water during summer in Arctic and Subarctic seas results in increased primary and secondary production, biomass may increase for some important commercial fish stocks and new mixes of species may become targeted by commercial fishers. In contrast, published studies suggest that in the Southern Ocean the potential for existing species to adapt is mixed and that the potential for the invasion of large and highly productive pelagic finfish species appears low. Thus, future Southern Ocean fisheries may largely be dependent on existing species.

Concluding remarks

The limited number of contributions that presented substantially new knowledge indicates that research on these themes is at an early stage. Increased research effort on how climate change impacts harvest in the Arctic, as well as on resident and non-native species in this part of the world, is needed. The topics covered by this theme session will, therefore, surely be taken up by future research on climate change impact in Arctic regions.

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